

PRECISION MACHINING TECHNOLOGY



PURPOSE

To evaluate each contestant's preparation for employment and to recognize outstanding students for excellence and professionalism in the field of precision machining technology.

First, refer to General Regulations, Page 9.

CLOTHING REQUIREMENT

Official SkillsUSA khaki work shirt and pants, black or brown leather work shoes, and safety glasses with side shields or goggles. (Prescription glasses can be used only if they are equipped with side shields. If not, they must be covered with goggles.) To purchase official work clothes, contact Midwest Trophy Manufacturing Co. Inc. by calling 800-324-5996 or order online at: www.mtmrecognition.com/skillsusa/.

Note: Contestants must wear their official contest clothing to the contest orientation meeting.

ELIGIBILITY

Open to active SkillsUSA members enrolled in programs with precision machining technology as the occupational objective.

EQUIPMENT AND MATERIALS

1. Supplied by the technical committee:
 - a. All necessary machines, workholding devices and work-piece materials
 - b. All necessary hand tools and precision measuring instruments needed by contestants and/or judges
 - c. All necessary personal computers and software for offline part programming
 - d. All necessary reference material, charts and work instructions to be used by contestants and/or judges
2. Supplied by the contestant:
 - a. Calculators are not required, but are allowed
Note: Contestants are not to bring any tools or reference materials to the contest
 - b. One-page, typewritten résumé

SCOPE OF THE CONTEST

The contest will be based on and consistent with the National Institute for Metalworking Skills (NIMS), Duties and Standards for Machining Skills, Levels I and II. Information on how to obtain these skill standards may be obtained directly from NIMS by calling 703-352-4971, or on the Web at <http://www.nims-skills.org/>. Competencies to be tested are determined by the SkillsUSA Championships technical committee.

Knowledge Performance

The contest will include written knowledge assessments that require the understanding of precision machining technology related knowledge (theory).

Wherever the words "demonstrate knowledge of" are used in the contest standards and competencies, the technical committee could include any of that subject matter in the written theory test that is administered on the Wednesday morning prior to the hands-on skill competition.

Skills Performance

The contest will include a hands-on skill competition. Each contestant in the SkillsUSA Championships is expected to demonstrate competency in manual machining performance skills. This includes: applying fundamental computational skills; interpreting engineering drawings; technical data and other graphics; applying physical science principles; setup and operation of manual metalworking machines; industrial safety and hygiene requirements; and use of a PC and keyboarding skills, using offline CNC programming software, and having the ability to program, set up and operate basic CNC machines.

Contest Guidelines

1. It should be understood that some of the standards and competencies beginning with the statement "demonstrate knowledge of" are also a normal part of the hands-on portion, such as reading engineering drawings, making calculations, etc.
2. Each year, the Precision Machining technical committee will devise and conduct an interview with each contestant as part of the contest.

3. Actual CNC machine setup and operation is not a requirement in the Precision Machining Technology competition. This section is covered in a separate NIMS Level II CNC contest area and is not part of precision machining technology.

Standards and Competencies

PMT 1.0 — Demonstrate machining-related computational competencies using both metric and U.S. customary units in accordance with related requirements identified in NIMS Machining Skills Level 1, KSAO Area 2: Mathematics

- 1.1 Apply basic arithmetic skills to solve problems.
- 1.2 Apply functional algebra, geometry, trigonometry to solve problems
- 1.3 Use formulas, handbook tables, charts and technical reports to solve problems or make decisions
- 1.4 Chart, interpret and explain statistical process control and inspection data
- 1.5 Calculate the correct amount of grind stock to be left on a part when doing roughing operations
- 1.6 Calculate center offsets for taper turning and compound slide settings for angle turning

PMT 2.0 — Demonstrate professional development competencies in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 7: Career Management and Employment Relations and in KSAO Area 4: Social Skills and Personal Qualities

- 2.1 In an interview situation, explain a technical issue related to precision machining technology such as sequence of operations, one piece vs. production setups; related non-machining operations such as heat treating, deburring, material handling, etc.
- 2.2 Analyze a specific machining related problem and then make an oral report
- 2.3 Respond to general questions that typically would be part of an employment type interview
- 2.4 Demonstrate poise, confidence and knowledge of the subject, oral communication skills, and the ability to react to new situations and to make sound decisions in an interview situation
- 2.5 From photographs, identify and explain the proper use or application of precision machining technology related machinery or tooling

- 2.6 From a list of modern precision machining technology related terms, explain the meaning of each term and discuss the current application of each term

PMT 3.0 — Demonstrate communication competencies in accordance with related requirements identified in NIMS Machining Skills 1, KSAO Area 1: Written and Oral Communication and KSAO Area 5: Engineering Drawing and Sketches

- 3.1 Using a MSDS sheet, determine and explain the steps to be taken related to the cleanup and reporting of a chemical spill in a typical machine shop situation
- 3.2 Read, interpret, conceptualize and be able to report (orally, handwritten note or paper document) common manufacturing processes related to precision machining and relate them to features of a part or engineering drawing of a part
- 3.3 Interpret single or multiple page engineering drawings or sketches (inch or metric) to determine features to be machined
- 3.4 Translate geometric tolerance symbols and other part specifications contained within feature control symbols used in machining and measurement (ASME Y14.5-1982)
- 3.5 Demonstrate knowledge and understanding of projection theory and other engineering drawing principles
- 3.6 Produce an appropriate freehand orthographic, oblique, isometric or perspective sketch of a part to be machined
- 3.7 Write or letter legibly
- 3.8 Enter, retrieve, update, change or analyze computer-stored data related to machining or inspection
- 3.9 Orally explain machining procedures and/or practices

PMT 4.0 — Use knowledge of physical science in precision machining situations in accordance with related requirements identified in NIMS Machining Skills Level 1, KSAO Area 7: Metal Working Theory

- 4.1 Demonstrate knowledge of principles of mechanics, machines, heat, light, sound and other forms of energy in relation to cutting and workholding tooling used in both manual and CNC machining
- 4.2 Describe the physical and/or metallurgical characteristics of cast irons, steels, nonferrous metals, composites, plastics and other materials that could be machined

- 4.3 Discuss the effects of heat-treating and coating processes on materials used for work pieces and/or cutting tools
- 4.4 Explain the process by which carbide and/or ceramic cutting tool inserts are made
- 4.5 Read and use machinability tables to determine the effect the work piece material has on such things as cutting speed, feed rate, depth of cut, cutter selection, tool wear, surface finish, etc.

PMT 5.0 — Demonstrate safety and hygiene competencies in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 6: Industrial Safety and Environmental Protection and in KSAO Area 4: Social Skills and Personal Qualities

- 5.1 Understand and practice safe operation of the machines now being used
- 5.2 Define and demonstrate an understanding of safety codes and rules used to safeguard self, other workers and the equipment and tooling
- 5.3 Apply good hygiene in the use of cutting fluids and/or other chemicals typically used for machining
- 5.4 Read, understand and follow a Material Safety Data Sheet (MSDS)
- 5.5 Demonstrate safe work habits when performing any of the machining, bench work, material handling or measurement competencies listed for this precision machining competition

PMT 6.0 — Perform competencies related to manual turning (lathe) operation in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 2: Job Execution

- 6.1 Set up machine for single or multiple part production, which includes setting machine stops, proper speeds, feeds and depth of cuts for the material to be machined and the type of cutting tools available
- 6.2 From the cutting tools available (could be HSS, cast alloys or carbide), select the best tool for the operation and mount properly
- 6.3 Perform basic turning operations: work between centers, three- or four-jaw chuck work, collet work, center drilling, straight turning, shoulder and end facing, chamfering, radius turning, grooving, cutting off, drilling, boring, reaming, taper and angle turning, roughing (leaving grind stock) and finishing, knurling, filing and polishing, and internal and external thread chasing

- 6.4 Demonstrate the ability to hold inch and/or metric dimensional, geometric and surface finish tolerance requirements
- 6.5 Identify and discuss the application of other types of lathes and the advantages of each

PMT 7.0 — Perform competencies related to manual milling machine operation in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 2: Job Execution

- 7.1 Set up machine for single or multiple part production, which includes setting machine stops, calculating proper cubic feet per minute, chip load, depth of cut, speeds and feeds for the material being machined, and the type of cutters available
- 7.2 Select the proper work-holding device and set it up correctly to withstand the cutting forces present
- 7.3 Make table setups, using straps and clamps, vise setups, V-block setups and indexing devices
- 7.4 Select the proper cutting tool holding device; mount it properly; determine correct direction of rotation; determine when a cutter is dull; be able to change inserts and chip breakers
- 7.5 Perform basic milling operations that include plain, face, end, side, form, angle, grooving, keyway/keyseat and cut-off
- 7.6 Set up and use a dividing head and/or rotary table
- 7.7 Tram in the machine head, milling vise or other work-holding devices
- 7.8 Demonstrate knowledge of cutter types, styles and materials

PMT 8.0 — Perform competencies related to manual drill press operation in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 2: Job Execution

- 8.1 Prepare machine and select proper RPM for the cutting tool being used
- 8.2 Select and safely mount work-holding device
- 8.3 Mount work piece in work-holding device
- 8.4 Select the proper cutting tool for the job
- 8.5 Perform drilling, countersinking, counter-boring, spot-facing, reaming and tapping operations
- 8.6 Demonstrate knowledge of drill press classifications and their applications
- 8.7 Demonstrate knowledge of common drill press cutting tool types and applications
- 8.8 Demonstrate knowledge of common drill press work-holding devices and their applications

PMT 9.0 — Perform competencies related to manual grinding machine operation in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 2: Job Execution

- 9.1 Demonstrate knowledge of surface, cylindrical, center-less and internal grinding machines and their applications
- 9.2 Set up and operate a manual horizontal reciprocating surface grinder
- 9.3 Perform surface grinding operations to produce flat, parallel, stepped and angled surfaces
- 9.4 Use a permanent magnet chuck (table) on a surface grinder
- 9.5 Determine proper in-feed, work speed and cross-feed speed
- 9.6 Dress the wheel
- 9.7 Demonstrate knowledge of grinding wheel characteristics, construction, standards and selection including: wheel markings, wheel shapes, proper storage for wheels and how to inspect a grinding wheel
- 9.8 Demonstrate knowledge of cutting fluids used in grinding operations
- 9.9 Demonstrate knowledge of super-abrasive technology and applications
- 9.10 Obtain and hold surface finish tolerances
- 9.11 Obtain and hold close inch or metric dimensional tolerances

PMT 10.0 — Perform competencies related to bench and hand tool use in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 2: Job Execution

- 10.1 Use layout hand tools (in conjunction with the measuring tool competencies listed in the next section) including coating materials, surface plates, v-blocks, scribes, dividers, trammels, keyseat rules, hemaphrodite calipers, angle plates, surface gage, and prick and center punches
- 10.2 Find the center of a square, cylindrical, rectangular work piece; layout bolt circles and hole locations; layout features to be produced
- 10.3 Properly use hammers, screwdrivers, files, chisels, wrenches, hand taps and tap wrenches, threading dies, hand reamers, hand hack saws and blade applications, and a bench vise
- 10.4 Deburr work pieces after machining or hand operations
- 10.5 Hand letter or number stamp parts

PMT 11.0 — Demonstrate the ability to use process control and measurement in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 3: Quality Control and Inspection and in KSAO Area 6: Measurement

- 11.1 Using current industrial engineering drawings and work pieces, make precision measurements for specific features
- 11.2 Select and use the proper measuring device (U.S. customary or metric) for the feature to be measured
- 11.3 Explain the reason for using calibrated measuring tools
- 11.4 Make the appropriate calculations to set up the measuring device or to mathematically determine location of part features
- 11.5 Demonstrate knowledge of and be able to select, assemble, and disassemble gage block sets using the least block method
- 11.6 Demonstrate knowledge of and ability to measure surface finishes
- 11.7 Be able to effectively use common precision machining measuring tools (U.S. customary or metric) such as steel rulers, combination square sets, depth gages, spring calipers, outside/inside/depth micrometers, vernier/dial/digital calipers, vernier/digital height gage, protractor, mechanical/electronic indicators, go/no-go gages; comparators; surface plates, angle plates, parallel blocks, inspection centers, sine bars/plates, and profilometer/surface finish comparison devices
- 11.8 Physically measure for: parallelism; squareness; roundness; concentricity; axial run-out; flatness; hole location/size; angles; tapers; threads; linear
- 11.9 Identify which manufacturing processes are capable of producing specific surface finishes economically
- 11.10 Demonstrate knowledge of the general classes of fits
- 11.11 Demonstrate knowledge of statistical process control (SPC) terminology and ability to use quality

PMT 12.0 — Demonstrate knowledge of power sawing processes

- 12.1 Demonstrate knowledge of power, hack and band sawing processes including: machine types and applications; work holding accessories; basic setup considerations; blade/band selection; special safety precautions

PMT 13.0 — Demonstrate knowledge of machinability

- 13.1 Identify and explain the components that boost machine performance and cut costs
 - 13.1.1 Use of optimum speeds and feeds when machining
 - 13.1.2 Selection of the best cutting tool for the material being machined
 - 13.1.3 Selection of proper cutting tool geometry related to horsepower of machine and the material being machined
 - 13.1.4 Capability of the machine to produce the tolerance required
 - 13.1.5 Selection of the most suitable measuring tool for the tolerance specified
 - 13.1.6 Testing for and maintaining machine geometries to manufacturer specifications
 - 13.1.7 Awareness of new or emerging precision machining technologies
- 13.2 Discuss the variables that could cause machining problems such as tool/work overhang, tool grade/geometry, machine condition/power, cutting fluid, shape of work, chip breakers, material hardness, etc.
- 13.3 Discuss what chip shape and color can tell you about optimum cutting
- 13.4 Discuss the relative machinability of steels

PMT 14.0 — Perform competencies related to CNC milling programming in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 2: Job Execution

- 14.1 Identify machine capabilities to determine proper speeds, feeds and depths of cuts for the cutting tools available and the material being machined
- 14.2 Complete the operational sequence required for machining linear and circular interpolation profiles
- 14.3 Use standard preparatory and miscellaneous function codes for straight line moves in the X, Y and Z axis
- 14.4 Use G02 and G03 codes for arcs and circles
- 14.5 Write a CNC program to machine a simple part using offline programming software on a personal computer
- 14.6 Verify the CNC program using graphic verification with offline programming on a personal computer
- 14.7 Demonstrate knowledge of types of CNC machines including machining centers; axes designations; advantages of CNC; CAD/CAM; work-holding systems; and cutting tools used with CNC machining

PMT 15.0 — Perform competencies related to CNC turning (lathe) programming in accordance with related requirements identified in NIMS Machining Skills Level 1, Duty Area 2: Job Execution.

- 15.1 Identify machine capabilities to determine proper speeds, feeds and depths of cuts for the cutting tools available and the material being machined
- 15.2 Complete the operational sequence required for machining cylindrical parts
- 15.3 Use standard preparatory and miscellaneous function codes for straightline moves in the X and Z axes
- 15.4 Use G02 and G03 codes for arcs and contours; macro code for the incremental feed command on a fixed cycle
- 15.5 Write a CNC program to machine a simple part using offline programming software on a personal computer
- 15.6 Verify the CNC program using graphic verification with offline programming software on a personal computer

PMT 16.0 — Demonstrate knowledge of flexible manufacturing systems and new technologies

- 16.1 Describe and explain trends and new manufacturing technologies that relate to precision machining such as CAD/CADD, CAE, CIM/CAM, CIM/GEN, PLCs, computer communication networks and information exchange, Internet's influence, high speed machining, LBM (Lasers Beam Machining), water jets, EDM (Electrical Discharge Machining), robots in production, rapid prototyping, net-shape/near-shape technologies, Just-In-Time, automated inspection/measurement, etc.

Committee Identified Academic Skills

The technical committee has identified that the following academic skills are embedded in this contest.

Math Skills

- Use fractions to solve practical problems
- Use proportions and ratios to solve practical problems
- Simplify numerical expressions
- Measure angles
- Find surface area and perimeter of two-dimensional objects
- Apply transformations (rotate or turn, reflect or flip, translate or slide, and dilate or scale) to geometric figures
- Construct three-dimensional models
- Make comparisons, predictions and inferences using graphs and charts

- Find slope of a line
- Solve practical problems involving complementary, supplementary and congruent angles
- Solve problems involving symmetry and transformation
- Use measures of interior and exterior angles of polygons to solve problems
- Find arc length and the area of a sector

Science Skills

- Use knowledge of the particle theory of matter
- Describe and recognize solids, liquids and gases
- Describe characteristics of types of matter based on physical and chemical properties
- Use knowledge of physical properties (shape, density, solubility, odor, melting point, boiling point, color)
- Use knowledge of chemical properties (acidity, basicity, combustibility, reactivity)
- Use knowledge of classification of elements as metals, metalloids, and nonmetals
- Describe phases of matter
- Describe and identify physical changes to matter
- Predict chemical changes to matter (types of reactions, reactants, and products; and balanced equations)
- Use knowledge of potential and kinetic energy
- Use knowledge of mechanical, chemical and electrical energy
- Use knowledge of heat, light and sound energy
- Use knowledge of temperature scales, heat and heat transfer
- Use knowledge of sound and technological applications of sound waves
- Use knowledge of the nature and technological applications of light
- Use knowledge of speed, velocity and acceleration
- Use knowledge of Newton's laws of motion
- Use knowledge of work, force, mechanical advantage, efficiency and power
- Use knowledge of simple machines, compound machines, powered vehicles, rockets and restraining devices
- Use knowledge of principles of electricity and magnetism

Language Arts Skills

- Demonstrate use of verbal communication skills, such as word choice, pitch, feeling, tone and voice
- Demonstrate use of nonverbal communication skills, such as eye contact, posture and gestures using interviewing techniques to gain information
- Use text structures to aid comprehension
- Demonstrate knowledge of appropriate reference materials
- Demonstrate informational writing
- Edit writing for correct grammar, capitalization, punctuation, spelling, sentence structure and paragraphing

Connections to National Standards

State-level academic curriculum specialists identified the following connections to national academic standards.

Math Standards

- Numbers and Operations
- Algebra
- Geometry
- Measurement
- Data Analysis and Probability
- Problem Solving
- Reasoning and Proof
- Communication
- Connections
- Representation

Source: NCTM Principles and Standards for School Mathematics. To view high school standards, visit: standards.nctm.org/document/chapter7/index.htm. Select "Standards" from menu.

Science Standards

- Understands the structure and properties of matter
- Understands the sources and properties of energy
- Understands forces and motion
- Understands the nature of scientific inquiry

Source: McREL compendium of national science standards. To view and search the compendium, visit: www.mcrel.org/standards-benchmarks/.

Language Arts Standards

- Students read a wide range of print and nonprint texts to build an understanding of texts, of themselves, and of the cultures of the United States and the world; to acquire new information; to respond to the needs and demands of society and the workplace; and for personal fulfillment. Among these

texts are fiction and nonfiction, classic and contemporary works

- Students apply a wide range of strategies to comprehend, interpret, evaluate and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies, and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, graphics)
- Students adjust their use of spoken, written, and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes
- Students employ a wide range of strategies as they write and use different writing process elements appropriately to communicate with different audiences for a variety of purposes
- Students apply knowledge of language structure, language conventions (e.g., spelling and punctuation), media techniques, figurative language and genre to create, critique, and discuss print and nonprint texts
- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate and synthesize data from a variety of sources (e.g., print and nonprint texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience
- Students use a variety of technological and information resources (e.g., libraries, databases, computer networks, video) to gather and synthesize information and to create and communicate knowledge
- Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion and the exchange of information)

Source: IRA/NCTE Standards for the English Language Arts. To view the standards, visit:
www.readwritethink.org/standards/index.html

CONTEST SCORECARD

Items Evaluated	Possible Points
Manual Engine Lathe Operation.....	125
Manual Milling Machine Operation.....	125
Manual Drill Press/Surface Grinder Operation ..	125
Process Control/Precision Measurement.....	125
CNC Programming—Turning	125
CNC Programming—Milling	125
Related Knowledge Written Test.....	150
Professional Development.....	100

Sub Total	1,000
Résumé Penalty	_____
Clothing Penalty	_____
TOTAL	_____